Development of Cost Estimation Methodology of Decommissioning for PWR

Sang Il Lee †, Yeon Jae Yoo, Yong Kyu Lim, Hyeon Sik Chang and Geun Ho Song
Hyundai Engineering Company Ltd., Mok-dong, Yangcheon-gu, Seoul, Korea
† Corresponding author: sang@hec.co.kr

1. Introduction

The 50 % of the operating nuclear power plants in the world is expected to be closed by 2030, which means to create a substantial market for the nuclear reactor decommissioning[1, 2].

Decommissioning is the complex process to deactivation, decontaminate, dismantle, demolish and dispose the nuclear power plant to environmentally remediate the nuclear site. That is why the decommissioning takes the longer time than the construction. Also, the permanent closure of nuclear power plant should be conducted with the strict laws and the profound planning including the cost and schedule estimation because the plant is very contaminated with the radioactivity.

In Korea, there are two types of the nuclear power plant. One is the pressurized light water reactor (PWR) and the other is the pressurized heavy water reactor (PHWR) called as CANDU reactor. Also, the 50% of the operating nuclear power plant in Korea is the PWRs which were originally designed by CE (Combustion Engineering).

There have been experiences about the decommissioning of Westinghouse type PWR, but are few experiences on that of CE type PWR. Therefore, the purpose of this paper is to develop the cost estimation methodology and evaluate technical level of decommissioning for the application to CE type PWR based on the system engineering technology [3].

2. Methods and Results

2.1 Methodology

System engineering is the interdisciplinary field of engineering that focuses on how to design and manage complex engineering projects over their life cycle. This deals with work-process, optimization methods, and risk management tools in such projects and ensures that all likely aspects of a project or system are considered, and integrated into a whole [3]. In order to apply the system engineering to the development of the cost estimation methodology of Decommission, the following scopes should be considered:

- Survey basic information of the plant and engineering
- Select the decommissioning scenarios
- Decide decommissioning scope
- Define the bill of material (BOM) of decommission;
- Develop work breakdown structure (WBS) including activities and cost information
- Search unit cost reflecting Korea labor productivity

In order to model the scenario-based WBS and Set structure, this paper uses the data modeling, process modeling and the object oriented modeling. The basic structure of this methodology is Task structure, Set structure and Work unit library that incorporates labor and waste information.

As shown in Figure 1, this methodology consists of Set, Subsets, Tasks and Subtasks which are incorporates more than one Work Unit.

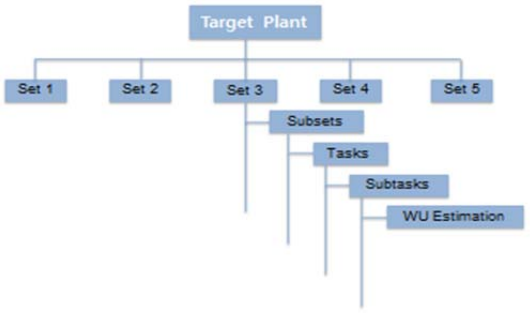

Figure 1 Decommission Work Outline of Nuclear Power Plant

2.2 Structure of the Modeling

2.2.1 SET Structure

Set structure represents the scope definition of target plants. Superset means the target plant such as PWR. The Superset (or target plant) incorporates several Sets that are mostly defined as buildings and/or facilities. And along the same line, each Set includes several Subsets. Each Subset mainly is applied to floor of the building of each Set. For example, the Subset of Primary Aux. Building Set of Hanul Unit 6 NPP consists of the 8 floors; Below slab EL.77', Slab EL.77 to Slab El.100'-6", Slab EL.125, Slab EL.144, Slab EL.165 & Roof & Above and Primary Auxiliary building general [4]. And not only the floor levels of the building, but also the things like site power and property taxes are applied as Subsets in Set 1 (Management & Support). Since these items should be considered for any project cost estimate. And all those

space classifications may depend on estimator's judgment. Set structure is derived from site specific general arrangements and plant configuration. Table 1 shows the result of Set structure of PWR reactor. The Set structure of Hanul Unit 6 consists of 29 Sets including management, support, the major buildings and facilities.

Table 1 Set structure of PWR reactor

No	Set	No	Set
1	Management & Support	16	Switchyard
2	Primary Aux. Building	17	Turbine Building
3	Aux. Boiler Building	18	Underground Utilities
4	Containment Building	19	N_2&H_2 Gas Storage Area
5	CCW Heat. Ex. Building	20	Circulating Water Intake
6	Yard Transformer Area	21	FP&W/W Treat Building
7	Fuel Building	22	Yard Facility
8	Guard House	23	Heater Bay
9	Cold Machine Shop	24	EDG
10	ESW Intake Structure	25	CO_2 Storage Tank/Room
11	Administration/Shop/Ware house General	26	Centrifuge and Pump House
12	Access Control Building	27	Shared Systems
13	Sec. Auxiliary Building	28	Site Restoration
14	Chlorination Building	29	Project Demobilization
15	Radwaste Building		

2.2.2 Task Structure

Each Task should be allocated into Set structure since the decommissioning of each buildings and facilities needs the tasks. And each Task consists of each subtask depending on the details of the Task. For example, some subtasks for dismantling mechanical in containment building are defined as steam generator removal, pressure vessel removal, tank removal, surface decontamination and auxiliary mechanical equipment removal. And the subtask list for other buildings is different [4]. Decision on subtasks is based on applicable Decommissioning works on each Set and Subset structure.

2.2.3 Work Unit

The Work units are generally developed to identify the lowest possible working level of the manpower, materials and equipment that may be needed to perform the identified work. It provides a basis for the estimation of cost unit of decommissioning works. Therefore, Work unit incorporates library information of labor and waste information. In this paper, some Work units are based on the information from the Korean experience of PWR and the ASME data [5] for estimating the decommissioning costs of PWR.

2.3 Result

Figure 2 shows the preliminary results of the decommissioning cost and schedule of Hanul Unit 6. To get the result of PWR NPP, the Set structure is generated as 29 Set lists. Task structure is formed as 15 categories with each Subtask. The preliminary result shows that the project durations and the required actual man power are near 5.7 years and 1,471 days, respectively.

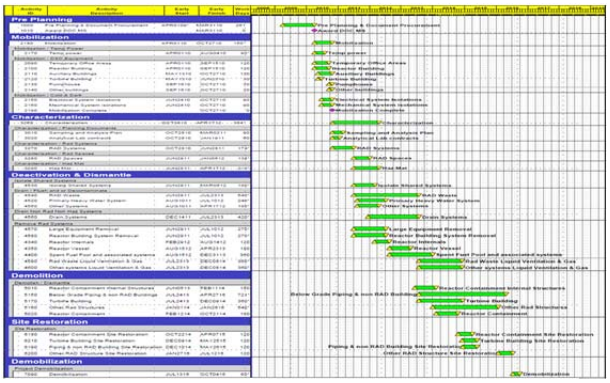

Figure 2 Result of cost and schedule estimation for PWR NPP

3. Conclusions

The aim of present study is to develop the cost estimation methodology of decommissioning for application to PWR. Through the study, the following conclusions are obtained:

- Based on the system engineering, the decommissioning work can be classified as Set, Subset, Task, Subtask and Work cost units.
- The Set and Task structure are grouped as 29 Sets and 15 Task s, respectively.
- The final result shows the cost and project schedule for the project control and risk management.
- The present results are preliminary and should be refined and improved based on the modeling and cost data reflecting available technology and current costs like labor and waste data.

REFERENCES

[1]"Closing and Decommissioning Nuclear Power Reactors", UNEP YEAR BOOK 2012.
[2] Laura Wood, "Research and Markets: Nuclear Reactor Decommissioning Industry - Global Market Size and Competitive Landscape Analysis to 2030,"August 31, 2013.
[3] G. A. Hazelrigg, "System Engineeing : An Approach to Information-Based Design", Prentice-Hall, 1996.
[4] Sun-Kee Lee, "Cost Estimating System Development for Decommissioning Nuclear Power Plants Lessons Learned from Korean Cost Estimate Project – 10196."March 7-11, WM Conference, Phonix, AZ., 2012
[5] The Decommissioning Handbook, ASME, 2004.